

Pediatric jellyfish envenomation in the Mediterranean Sea

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Background Several species of jellyfish native to the western Indian Ocean have entered the Mediterranean Sea through the Suez Canal. Since the late 1980s, each summer *Rhopilema nomadica* forms swarms as long as 100 km in the southeastern Levant and since the millennium aggregations of additional nonnative jellyfish have been sighted. The aim of this study was to evaluate children seen in the emergency department after jellyfish envenomations and to establish patterns of toxicity associated with this organism.

Methods A retrospective chart review was performed of all children presenting after jellyfish envenomations to the pediatric emergency department during the jellyfish swarming seasons (June–August) between 2010 and 2015. Extracted data included age, location of envenomation, pain scores, local and systemic manifestations, treatment provided in the emergency department and hospital, and disposition.

Results Forty-one patients fulfilled the inclusion criteria; their ages ranged from 1 to 16 years and the median age was 9.4 years. Clinical manifestations were evident in all patients. Pain, present in 100% of patients, and an erythematous, whip-like, linear rash present in 87.8%, were the most common manifestations. The majority of ‘burns’ associated with jellyfish stings were first and second degree. The upper limb was affected in 34% and the lower limb was affected in 61% of cases. One patient suffered a sting to the abdomen and three patients suffered a sting to the face. Treatment in the emergency department included pain control, with nonsteroidal anti-inflammatory drugs and opiates, and antihistamines and topical corticosteroids in some cases. Nearly 49% of patients were seen during the

summer of 2015 alone and seven patients in this group needed hospitalization. Reasons for hospitalization included systemic symptoms such as fever, chills, tachycardia, and muscle spasms. Two patients developed severe cellulitis, one patient had an anaphylactic reaction, and one was admitted to the ICU after suffering an anaphylactic reaction to a sting sustained while surfing.

Conclusion The prevalence of the jellyfish swarms and the severity of clinical manifestations because of their envenomations suggest that it should be considered as a health hazard in the Mediterranean Sea. We call for public health authorities in affected countries to initiate a health hazards database, familiarize medical and healthcare staff with the clinical syndromes, train medical and healthcare staff in appropriate treatment, and initiate and continue public awareness campaigns. *European Journal of Emergency Medicine* 00:000–000 Copyright © 2017 Wolters Kluwer Health, Inc. All rights reserved.

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Background

The nomadic jellyfish *Rhopilema nomadica* is native to the Western Indian Ocean and the Red Sea [1]. The first occurrence of *R. nomadica* in the Mediterranean Sea was reported in the mid-1970s, off the coast of Israel [2]. Although other species of jellyfish, such as *Cassiopea andromeda*, *Cotylorhiza erythraea*, and *Marivagia stellata*, have been documented in the Mediterranean Sea [3–5], the main envenomating species is *R. nomadica* [2]. This species has since spread throughout the Levant and was recently reported as far afield as Pantelleria, Italy, Malta, and Tunisia, where, in 2013, densities as high as 10–100 jellyfish/1000 m³ were observed and beaches were strewn

with stranded specimens (one organism/m²) [6]. Each summer since the late 1980s, *R. nomadica*, has formed 100 km long swarms in the southeastern Levant [2]. The swarming of *R. nomadica* has become a regular occurrence during the summer months when beach use by bathers, surfers, and other recreationists is highest. Following such outbreaks, local municipalities in Israel have reported a decrease in vacationers frequenting the beaches because of concern over the painful stings inflicted by the jellyfish [7].

The venom apparatus of *R. nomadica* consists of nematocyst-laden tentacles. These cell organoids consist

of a capsule containing a tightly coiled and a pleated tubule armed with spines and packed with venom. When stimulated, the coiled tubule everts, penetrating the epidermis of human skin, and venom is injected from the capsule through the tubule into the tissue of the victim [8]. Three categories of nematocysts have been identified in *R. nomadica*: heterotrichous isorhiza haploneme, holotrichous isorhiza haploneme, and heterotrichous microbasic eurytele [9]. The venom mostly contains enzymatic polypeptides, including a heat-stable phospholipase A₂ that hydrolyzes the phospholipids of epithelial cells, leading to lysis. This mechanism is strongly temperature dependent. Other important polypeptides are hemolysin and protease [10]. The severity of envenomation is related to the number of nematocysts discharged, volume of venom delivered, and the general condition of the victim [11].

Envenomation typically leads to immediate pain, erythema, a burning sensation, development of a papulovesicular eruption, and delayed skin reactions [12]. Eruptions are because of immediate hypersensitivity reactions, acute venom toxic effect, and persistent inflammatory responses [13]. Although envenomations are usually self-limited and do not require emergency care, many children developed systemic symptoms after envenomation in the summer of 2015 and some required hospitalization. The aim of this study was to describe the clinical course of pediatric patients presenting to the emergency department of a busy tertiary care pediatric hospital in a coastal metropolitan area after presumed envenomation by *R. nomadica*.

Methods

This was a retrospective chart review of all children seen in the pediatric emergency department at the Dana-Dwek Children's Hospital in Tel Aviv, Israel, after jellyfish envenomations during the three summer months (June–August) between 2010 and 2015. Demographic information, clinical data, local and systemic manifestations, complications, morbidity, and treatment were extracted from medical charts. The diagnosis of *R. nomadica* was established by history and identification of putative jellyfish from photographs. The National Institute of Oceanography confirmed that this was the prevalent jellyfish species at the time of the study (BG Coauthor, personal communication, June 2016). Each chart was reviewed and analyzed for the date of sting, patient age and sex, time elapsed since the sting, affected anatomic area, and systemic and local manifestations. Among the admitted patients, indication for admission, days of admission, and laboratory findings were analyzed. The study was approved by the hospital research ethics committee.

Data were transferred to an electronic spreadsheet (Excel 2007; Sourasky Medical Center, Tel Aviv, Israel) and subjected to a descriptive and comparative analysis. Demographic and clinical features are shown as numbers

or percentages for categorical variables, and as the median and the 25th and 75th percentiles interquartile interval for continuous variables. Statistical comparisons of continuous variables were performed using nonparametric association tests (χ^2 or Fisher's exact test), with *P* less than 0.05 indicating significance.

Definitions

Pain was measured using age-appropriate scales: for children younger than 7 years of age, pain was assessed using the Faces Pain Scale – revised [14], which utilizes a picture scale with faces expressing different levels of pain. For children 7 years of age and older, a visual analog scale 100 mm in length, anchored by the terms 'no pain' to 'worst possible pain', was used [15].

We used the Pediatric Advanced Life Support (American Heart Association) parameters for defining tachycardia and hypotension in accordance with age [16].

1–2 years: 98–140 beats/min.

3–5 years: 80–120 beats/min.

6–11 years: 75–118 beats/min.

12–15 years: 60–110 beats/min.

≥ 16 years: > 100 beats/min.

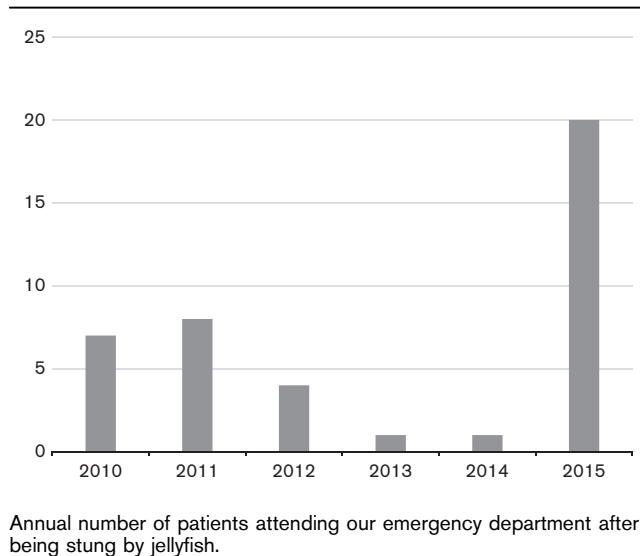
We defined hypotension as a systolic blood pressure less than fifth percentile for age.

Results

During the 6-year study period, a total of 41 patients presented to the emergency department after jellyfish envenomation, and only one by ambulance. The rest were brought by their parents as our hospital is very near to the beach. Ages ranged from 1 to 16 years, with a median of 9.4 years; 22 (53.7%) were females. The interval between envenomation and presentation to hospital ranged from 30 min to 48 h. Most stings (43.9%) occurred between June and August of the year 2015 (Fig. 1). All patients included in this study suffered their injuries in Tel Aviv metropolitan area beaches during recreational activities during daylight hours.

Clinical manifestations were evident in all victims. Thirty six (87.8%) presented with local, minor skin damage, three (7.3%) with local, skin damage including cellulitis, and seven (17%) with systemic signs and symptoms (Table 1). Of this latter group, the most common manifestations were tachycardia (7/7), fever and chills (4/7), and vomiting (4/7). Seven patients were admitted to hospital, all of them in 2015 (Table 2); three presented with a systemic inflammatory response consisting of tachycardia, fever, chills, leukocytosis, and elevated C-reactive protein. Two presented with cellulitis 48 h after the jellyfish sting and were treated with an intravenous antibiotic first-generation cephalosporin, intravenous fluids, and local treatment for burns. One patient

Fig. 1

Table 1 Demographics, clinical manifestations, and outcomes of children stung by *Rhopilema nomadica*

Patients (N = 41)	
Demographic data	
Age [median (IQR, limits)] (years)	9.4 (6.2–12.2, 1–16)
Male [n (%)]	19 (46)
Clinical manifestations [n (%)]	
Area of injury	
Upper extremity	14 (34)
Lower extremity	25 (61)
Trunk	4 (10)
Face	3 (7)
Toxic reaction	
Local minor skin damage	36 (87.8)
Local skin damage with cellulitis	3 (7.3)
Systemic reaction	7 (17.0)
Allergic reaction	
Local reaction	1 (2.4)
Generalized (anaphylaxis)	1 (2.4)
Systemic symptoms	
Vomiting	4 (9.7)
Respiratory distress	1 (2.4)
Chills	4 (9.7)
Muscle spasms	2 (2.4)
Vital signs	
Fever	4 (9.7)
Tachycardia	7 (17)
Hypotension	1 (2.4)
Pain score (n = 36) [median (IQR, limits)]	4 (0–6.75, 0–10)
Hospitalization (n = 7, all in 2015)	
Duration (median, IQR, limits) (days)	2, 1–2, 1–3
Ward [n (%)]	6 (86)
ICU [n (%)]	1 (14)
Treatment in the emergency department	
Local treatment	
Analgesia	40
Opiate	7
Nonopiate	20
Antihistamine	13
Corticosteroid	6
Oral antibiotic	6
Adrenalin	1
Intravenous fluids	7

IQR, interquartile interval.

required a 3-day admission; he was a 10-year-old boy who was stung on his face, and developed buccal swelling, mild dyspnea, and trismus. He was treated with oral antihistamines and corticosteroids. One patient developed anaphylaxis and was admitted to the ICU. She had developed immediate respiratory distress, hoarseness and pruritis after a jellyfish envenomation sustained while surfing off a Tel Aviv beach, and was brought, by ambulance, to the emergency department, having received intramuscular epinephrine en route. She presented with periorbital swelling and facial edema as well as hypotension that improved with intravenous fluids, systemic steroids, and antihistamines. She was discharged 2 days later with allergy service follow-up at our institution.

Some patients suffered envenomations in multiple areas, the upper limb was affected in 34% and the lower limb in 61% of cases; four patients were stung on the trunk and one on the face. Most patients manifested a painful, erythematous, whip-like, linear rash [40 (97.5%)]. Most ‘burns’ were first degree (87.8%). Of the six patients with second-degree burns, two were treated with surgical debridement and dressings, and two, who presented at 48 h, required plastic surgery consultation and follow-up. The remaining patients were followed by their community physician. Seven (17%) patients received opiate and 20 (48.7%) received nonopiate, analgesics.

Discussion

In our series of 41 children, presumed to have been stung by *R. nomadica*, most presented in 2015 and had systemic manifestations. During the summer of 2015, swarms of *R. nomadica* spread along the Israel Mediterranean coast from Ashkelon (south) to Nahariya (north), for a distance of 400 m and more from the coastline. Particularly large concentrations were reported in Haifa Bay, where beaches were littered with hoards of jellyfish (Fig. 2).

Envenomations such as those we have documented have been reported all along the Mediterranean coast, and local municipalities have reported a decrease in beach attendance during periods of jellyfish swarming [7]. *R. nomadica* is the largest and most venomous scyphozoan jellyfish present in the Mediterranean Sea. Its swarming behavior translates into a health hazard along large swaths of recreational beaches. Its sting commonly causes immediate severe pain, followed by an erythematous, whip-like, linear rash with a ‘frosted ladder’ appearance [17]. Some possible reasons why children may suffer increased morbidity include their higher surface area to weight ratio, their tendency to stay in the water for longer periods of time, and their reduced understanding of their environment.

Systemic signs and symptoms following envenomation include nausea, vomiting, muscle spasms, headache, malaise, fever, and chills. The pain generally abates over several hours, although the rash may persist for days, and

Table 2 Characteristics of children requiring hospitalization during 2015

Age (years)/sex	Body area	Clinical and laboratory observations	Treatment	Duration of hospitalization (days)
7.5/M	Arm	Tachycardia, fever, chills, leukocytosis, elevated CRP	Intravenous antibiotic Tetanus immunoglobulin Intravenous fluids	2
3.9/F	Arm, hips	Tachycardia, fever, chills	Oral opiates Topical cream: chloramphenicol 3.0% prednisolone 0.5%	1
6.3/F	Arm, hand, leg	Cellulitis, leukocytosis, elevated CRP	Intravenous antibiotic Topical sulfadiazine	2
10.5/M	Face	Anaphylactic reaction	Intravenous antibiotic Oral antihistamine Oral steroid Topical sulfadiazine	3
9.7/F	Hip	Tachycardia, cellulitis, leukocytosis	Intravenous antibiotic Oral antihistamine	1
9.5/F	Leg	Fever, chills, leukocytosis, elevated CRP	Intravenous antibiotic Oral antihistamine Topical sulfadiazine	1
15/F	Arm	Severe anaphylactic reaction	Intramuscular adrenaline Oral antihistamine Oral steroid Intravenous fluids	2

CRP, C-reactive protein; F, female; M, male.

Fig. 2

Rhopilema nomadica. Photo by R. Gevili taken off the Ashdod coast, Israel in 2014.

there can also be a delayed hypersensitivity reaction in the form of a pruritic, maculopapular rash [18]. For these reasons, all patients were prescribed topical antihistamines and topical corticosteroids after being discharged from the hospital. Elevated serum antisea nettle immunoglobulins IgM, IgG, and IgE may persist for years in patients with exaggerated reactions to stings compared with controls [19,20]. This could partially explain the more severe manifestations encountered in 2015.

Urticaria is secondary to the release of various mediators of inflammation, including serotonin, histamine, or histamine-releasing agents in the venom [21]. This may

explain the local dermonecrotic and systemic cardiorespiratory events that can occur after envenomation. The severity of injury is related to the area affected and depends on individual sensitivity [9], as well as the chemical composition of the venom, number of nematocysts discharged, and the general condition of the victim.

Aside from the one patient administered epinephrine in the ambulance, patients treated for jellyfish stings at the emergency department had not received first-aid before arrival as our hospital is not far from the seashore. The majority of patients with stings who do seek medical care experience severe pain without evidence of systemic poisoning; however, severe systemic manifestation can develop [20]. In most patients, pain can be adequately controlled with nonsteroidal anti-inflammatory medications, although opioids may be required under some circumstances [22]. General supportive measures for systemic reactions include oral antihistamines and oral corticosteroids. Local dermatitis can be treated with a topical corticosteroid cream [23].

Our patient whose anaphylactic reaction was aborted by timely intervention probably reacted on this occasion because of having been sensitized by receiving multiple stings in the recent past. Management of a life-threatening anaphylactic reaction requires simultaneous evaluation and management of the airway, breathing, and circulation, as well as the immediate administration of epinephrine. Corticosteroids are frequently recommended because of known efficacy in other allergic diseases. H₁-receptor antihistamines such as diphenhydramine are also indicated in histamine-mediated allergic reactions.

To confirm allergy to jellyfish, allergy tests such as prick-to-prick skin testing and immunoblotting for antigens to IgE antibodies using jellyfish materials can be performed [19]. Laboratory evaluation is not necessary for patients seen in the emergency department. The seven patients who were admitted underwent urinalysis and blood testing for hematocrit and serum creatinine, both of which were normal.

Successful media campaigns in Israel inform lifeguards, coastal first-aid providers, and the public on the health hazards of *R. nomadica*, but envenomations continue to occur [1].

Jellyfish species of concern to human health have recently gained notoriety, but broad assessments, either taxonomic or geographic, have been lacking [24]. Information is even more limited for other marine species. Among the 750 multicellular species recorded in the Mediterranean Sea, nine are noted as human health hazards – six fish, a sea urchin, a hydrozoan, and the nomadic jellyfish. All originate in the Indian Ocean or the Pacific Ocean, and are considered to have entered the Mediterranean through the Suez Canal. With increasing temperatures, it is likely the geographic spread of the thermophilic species will expand, including those constituting health hazards.

Although published records attest to the increasing spread and abundance of marine species of concern to human health, only fragmented information is available on the spatial and temporal trends of their impact. In fact, even for common species causing acute symptoms such as *R. nomadica*, incidents are poorly documented. Öztürk and İsinibilir [25] reported that, in the summer of 2009, *R. nomadica* envenomation caused 815 hospitalizations along the southeastern coast of Turkey, but no data are available for other years and other locations. The lack of nation-wide, if not region-wide, databases documenting the health impacts of envenomations such as these is worrisome. Ignorance as to the extent and severity of these health hazards and their treatment may lead to medical errors [26] and may prejudice risk analyses carried out by healthcare providers.

There are limitations to our study. First, it is retrospective in design. Second, the data were obtained from a single institution and management strategies and outcomes may, of course, vary between institutions.

Conclusion

Medical and healthcare staff should be familiarized with clinical syndromes and trained in the treatment of marine health hazards. Early diagnosis and supportive management helps ensure recovery. As incidents involving large numbers of patients may be expected to become more frequent with changing environmental conditions, healthcare systems should be well prepared by public health authorities. Public health authorities in

Mediterranean countries should be encouraged to initiate and sponsor a national health hazards database, sourced from hospital and ‘first-aid’ facility data. This information could be analyzed for injury location, date, speciation, symptoms, treatment, and outcomes. The information would allow healthcare authorities to manage trends in marine health hazards; ecologists could establish trends and the impact of bioinvasion by foreign species, economists could evaluate costs, and environmental authorities could perform accurate and detailed risk assessments. Public awareness campaigns of marine health hazards and their treatment should be conducted annually at the start of the summer. Multilingual signage should be placed at beaches to notify locals and tourists.

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Conflicts of interest

There are no conflicts of interest.

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